DIETARY ZINC SUPPLEMENTATION IN DAIRY COWS DURING TRANSITION PERIOD AFFECT ZINC, CHOLESTEROL AND FAT CONTENT IN MILK

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Abstract

The objective of present study was to investigate the effect of supplementing Zn in transition diet on zinc, cholesterol and fat content in milk. Twenty dairy cows (FH) were randomly assigned to 2 group: basal diet (control group; CON) and basal diet with supplementation of Zn 40 ppm (Con +Zn). Zn milk content were determined by atomic absorption spectrophotometry. Cholesterol and fat content in milk were measured with Biolabo kit and spectrophotometry. Cows were milked twice daily and throughout the experiment animal health was monitored daily. Milk samples (morning and afternoon milking) were taken at week 1-4 after calving. Results showed that Zn content in milk were higher in group CON + Zn compared with control group. In addition, milk fat and milk cholesterol were also affected by dietary Zn content in transition diet. No significant differences in milk production were observed between the 2 groups. In conclusion Zn supplementation increased Zn content, milk fat and cholesterol of dairy cows in early lactation. There is no negative effect on milk yield and total solid of the milk It seems feeding Zn above the requirements before calving not only maintain immune status but also increase milk quality and composition.

Keywords: *lipid metabolism, mineral status, milk composition, diet, dairy cows*

INTRODUCTION

At the onset of lactation, cows experience negative energy balance due to high requirement for milk production and maintenance, on the other hand energy intake from the feed is low due to low feed intake. Negative energy balance were associated with metabolic disorder, oxidative stress and inflammatory biomarkers during transition period (Mayasari et al., 2017). In the transition period, cows are more vulnerable to diseases and premature culling after calving due to increased physiological stress (Ducháček et al., 2020). Since body reserves must be mobilized to meet the rising energy requirements for the initiation of milk production, the transition from nonlactating to lactating is a crucial time for dairy cow lipid metabolism. Severe negative energy balance affected lipid metabolism It is unknown whether negative energy balance in early lactation will also has an impact on milk quality and composition (milk fat and cholesterol). Studies of lipid homeostasis including cholesterol homeostasis of transition dairy cows remained unclear. The cause of low plasma cholesterol and triacylglyceride (TAG) levels in cows at the start of lactation is unknown. Whether this is due to impaired hepatic export mechanisms or an increased transfer of these compounds into the milk to provide vital nutrients for the newborn is unknown (Kessler et al., 2014). The duration of a negative energy balance cycle can have an impact on milk quality, primarily through its impact on milk composition (Ducháček et al., 2020). Supplementation of trace mineral such as Zinc (Zn) known not only known improved immune status and minimize negative energy balance of dairy cows in early lactation but also it might be regulated in fat and cholesterol

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metabolism and might be affected milk quality and composition.

Zinc (Zn) is an important trace element mineral after iron (Fe). Micro minerals are minerals that the body needs in amounts of 100 mg or less per day (Linder, 1991). Zn is not only needed by various organs of the body, such as skin and gastrointestinal mucosa, but almost all cells need this mineral. Zinc is a mineral that is required for the catalytic activity of over 100 enzymes and is involved in immune function, protein synthesis, and cell division. Zn is a component of several enzymes (metaloenzymes, a.l superoxidase dismutase, carbonic anhydrase). Zn has an important role in maintaining the balance of functions of several tissues and has an important role in modulation of the immune system (Akhuemokhan et al., 2013). Zn plays a role in various aspects of metabolism, related to the synthesis and degradation of proteins, carbohydrates, lipids and nucleic acids. Zn can affect various organs such as the pancreas, prostate and mammary glands. Zn can fight free radicals and maintain antioxidant status in the body (Kelleher et Lönnerdal, 2005). The need for Zn in dairy cows is 40 ppm (NRC, 2001).

Zn deficiency is characterized by decreased function of immune cells in dealing with infectious agents. Zn is able to play a role in increasing the response to immune response non-specifically or specifically. Impaired immune response causes changes in resistance to infection. Therefore, the adequacy of the mineral Zn needs attention given its role in increasing the immune system and its effect on livestock productivity, inhibits the occurrence of apoptosis, namely programmed cell death which is regulated by genes (Truong-Tran et al., 2000). Our previous study showed that Zn intake increase Ca and Zn content in milk and blood (Mayasari et al., 2019). Moreover, recent study showed that feeding ZnAA increased protein, fat and Zn content in milk and cheese (Xu et al., 2021). Increasing Zn content in dairy products by feeding Zn to dairy animals was a promising process (Martino et al., 2019; Ianni et al., 2019).

Zn is essential mineral not only for livestock but also for human (important for children and pregnant woman). Therefore, consumers today expect their foods to be of high quality and have health benefits (Azzurra et Angela, 2018). As a result, Zn-enriched dairy products should be used for food processing. The effects of feed Zn supplementation especially during transition dairy cows on Zn, cholesterol and fat content in milk, on the other hand, are unknown. The aim of our research was to see how feed Zn supplementation affected the results.

MATERIAL AND METHODS

Animals and Experimental Design

All the data including animals and experimental design of this study were obtained from the project of INDIGO-MINERAL at Laboratory of animal physiology and biochemistry, Department of Animal Nutrition and Feed Technology, Universitas Padjdjaran, Indonesia. The Institutional Animal Ethic Committee of Universitas Padjadjaran approved the experimental protocol. Twenty Holstein Friesian dairy cows were selected from the Breeding centre of Dairy cows UPTD BPPIBTSP Bunikasih, Cianjur, Indonesia). Cows were blocked for parity (primiparous or multiparous). Dairy cows were assigned randomly to two dietary treatments. Treatments are a control group (CON, n=10) and group with Zn supplementation (CON + Zn, n=10).The doses of Zn supplementation were 40 mg/kg DM (according to Nutrient Requirements of Dairy Cattle (NRC, 2001). Zn content was analysed with atomic absorption spectrophotometry. Cholesterol in milk were measured with Biolabo kit and spectrophotometry. Milk fat concentrations were measured by an infrared analyzer (MilkoScan FT-6000, Foss Analytical). Drinking water was available at all times. Table 1 shows the nutrient content of feed ingredients, as well as the ration composition and chemical content of basal diet.Cows were housed in a free stall with a slatted floor and cubicles and were milked twice daily (0500 and 1630 h). Milk samples stored at -20°C until analysis. The data collected were statistically analyzed using analysis of covariance. Analysis of covariance was performed with dietary treatments as fixed effect for all cows.

Table 1 Ingredients and composition (% of DM unless otherwise noted) of basal diet

Item	Value
Ingredient	
Napier Grass	45.0
Consentrate	40.0
Legum *Indigofera zollingeriana*	15.0
Total	100.0
Chemical profile	
Dry Matter (DM)	53.50
Ash (%)	13.03
Crude Protein (%)	16.57
Crude Fat (%)	5.15
Crude Fiber (%)	21.45
TDN (%)*	59.52
Ca (%)	0.61
Zn (mg/kg DM)	82.92

* TDN = Total Digestible Nutrient

RESULTS AND DISCUSSION

In the present study, supplementation of mineral Zn in the diet during transition period increased Zn in milk (25%) (figure 1), increased milk cholesterol and milk fat (Figure 2) compared with control diets. Our study is in line with previous studies that feeding Zn in the cows diet increased Zn and fat content in milk (Xu et al., 2021; Ianni et al., 2019; Azzurra et Angela, 2018).

The concentration of Zn in milk is varies between treatments. The concentration of the Zn both in blood and in milk were affected by the supplementation doses, type of Zn (organic or inorganic), stage lactation of the cows, energy balance status of the cows, diet, health and immune status of the cows. Homeostasis of mineral in dairy cows is important and were related to the process in mammary gland. Mineral absorption into the secretory mammary epithelial cell (MEC), followed by mineral secretion from MEC into the alveoli lumen of the mammary gland for sequestration in milk, and finally milk release in response to suckling, are all needed for maintaining milk trace mineral homeostasis (Kelleher et Lönnerdal, 2005). It is important for human health to consume enough Zn on a daily basis. Increased Zn concentrations in raw milk can provide a suitable source of Zn for humans, particularly those who do not consume enough meat, to maintain physiological levels despite deficient Zn storage capabilities. Milk items, according to (Coudray, 2011), are a major source of dietary Zn in infants.

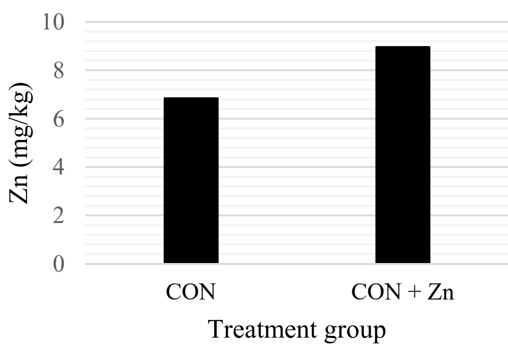

Figure 1. Zn content in milk from the 2 experimental group (CON=basal diet and CON+Zn=basal diet and Zn supplementation daily) ($P<0.05$)

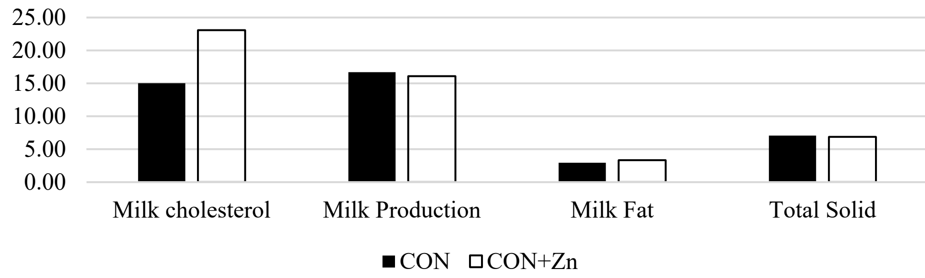

Figure 2. Milk cholesterol, milk production, milk fat and total solid of milk from the 2 experimental group (CON=basal diet and CON+Zn=basal diet and Zn supplementation daily) ($P<0.05$)

Milk fat is one of the most important sources of cholesterol in humans' everyday diets. The amount of fat and cholesterol in milk varies greatly between species, breeds, and herds, and is affected by a variety of factors such as genetics and diet. In dairy cows, nutritional and energy deficiency affected cholesterol metabolism depending on lactation level. Genetics, physiological level, and diet all play a role in modulating the expression of genes involved in cholesterol synthesis in cows. The precise roles of the various genes and their sequence variants in controlling cholesterol synthesis and content in bovine milk, however, have not been determined (Gross et al., 2015). Previous study reported that cholesterol levels in dairy cow's milk were 23.8 mg / dL (Reklewska et al., 2002). Milk cholesterol levels in this study are in the normal range. However, cholesterol levels in the control treatment or without Zn supplementation were below normal limits. Cholesterol in milk is obtained from the blood and from de novo synthesis in the mammary glands (Kessler et al., 2014).

CONCLUSION

Supplementation of Zn in the diet around parturition increased Zn and cholesterol content in milk. Zn supplementation in the diet during transition period did not give any negative effect on milk production and total solid and fat in milk which partly explain by improving immune status of the cows and enhanced milk quality. These results may aid in the production of functional, nutrient-dense dairy products.

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REFERENCES

1. Akhuemokhan I., Eregie A., Fasanmade O. (2013). Diabetes prevention and management: the role of trace minerals. 2013.
2. Azzurra A., Angela M. (2018). Consumer Perception of Sustainability Attributes in Organic and Local Food. Recent Patents on Food, Nutrition & Agriculture. 2018;9(2):87-96.
3. Coudray B. (2011). The Contribution of Dairy Products to Micronutrient Intakes in France. J Am Coll Nutr. 2011;30(sup5):410S-4S.
4. Ducháček J., Stádník L., Ptáček M., Beran J., Okrouhlá M., Gašparík M. (2020). Negative Energy Balance Influences Nutritional Quality of Milk from Czech Fleckvieh Cows due Changes in Proportion of Fatty Acids. Animals. 2020;10(4):563.
5. Gross J.J., Kessler E.C., Albrecht C., Bruckmaier R.M. (2015). Response of the cholesterol metabolism to a negative energy balance in dairy cows depends on the lactational stage. PLoS ONE. 2015;10(6):e0121956.
6. Ianni A., Iannaccone M., Martino C., Innosa D., Grotta L., Bennato F., et al. (2019). Zinc supplementation of dairy cows: Effects on chemical composition, nutritional quality and

volatile profile of Giuncata cheese. Int Dairy J. 2019; 94:65-71.
7. Kelleher S.L., Lönnerdal B. (2005). Molecular regulation of milk trace mineral homeostasis. Molecular Aspects of Medicine. 2005; 26(4):328-39.
8. Kessler E., Gross J.J., Bruckmaier R., Albrecht C. (2014). Cholesterol metabolism, transport, and hepatic regulation in dairy cows during transition and early lactation. Journal of Dairy Science. 2014;97(9):5481-90.
9. Linder M.C. (1991). Nutritional biochemistry and metabolism: with clinical applications.
10. Martino C., Ianni A., Grotta L., Pomilio F., Martino G. (2019). Influence of Zinc Feeding on Nutritional Quality, Oxidative Stability and Volatile Profile of Fresh and Ripened Ewes' Milk Cheese. Foods. 2019;8(12):656.
11. Mayasari N., Chen J., Ferrari A., Bruckmaier R.M., Kemp B., Parmentier H.K. (2017). Effects of dry period length and dietary energy source on inflammatory biomarkers and oxidative stress in dairy cows. Journal of Dairy Science. 2017;100(6):4961-75.
12. Mayasari N., Nurjanah L.T., Setyowati E.Y., Salman L.B. (2019). Effect Of Zinc Intake During Transition Period On Zinc And Calcium In Milk Of Subclinical Hypocalcemia Dairy Cows. Scientific Papers-Animal Science Series: Lucrări Ştiinţifice - Seria Zootehnie, 72:28-32.
13. NRC. (2001) Nutrient Requirements of Dairy Cattle: Seventh Revised Edition, 2001: The National Academies Press.
14. Reklewska B., Oprzadek A., Reklewski Z., Panicke L., Kuczyńska B., Oprzadek J. (2002). Alternative for modifying the fatty acid composition and decreasing the cholesterol level in the milk of cows. Livestock Production Science. 2002;76(3):235-43
15. Truong-Tran A., Ho L., Chai F., Zalewski P. (2000). Cellular zinc fluxes and the regulation of apoptosis/gene-directed cell death. The Journal of nutrition. 2000;130(5):1459S-66S.
16. Xu N.N., Yang D.T., Miao C., Valencak T.G., Liu J.X., Ren D.X. (2021). Organic zinc supplementation in early-lactation dairy cows and its effects on zinc content and distribution in milk and cheese. JDS Communications. 2021.

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